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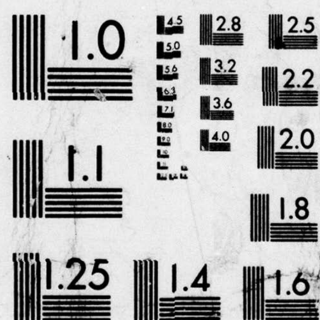

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DEFENSE SYSTEMS MANAGEMENT COLLEGE

PROGRAM MANAGEMENT COURSE
INDIVIDUAL STUDY PROGRAM

PROTOTYPING: A STRATEGY FOR
THE ACQUISITION OF NAVAL AIRCRAFT

STUDY PROJECT REPORT
PMC 76-2

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DEFENSE SYSTEMS MANAGEMENT COLLEGE

STUDY TITLE: PROTOTYPING: A STRATEGY FOR THE ACQUISITION OF NAVAL AIRCRAFT

STUDY PROJECT GOALS: TO ANSWER THREE RESEARCH QUESTIONS:

1. DO THE ECONOMICS OF DEFENSE SPENDING WEIGH IN FAVOR OF A PROTOTYPE ACQUITION STRATEGY?
2. WHAT IS MEANT BY PROTOTYPING AND WHAT ARE THE ADVANTAGES TO BE OBTAINED FROM A PROTOTYPE PROGRAM?
3. SHOULD A PROTOTYPE ACQUISITION STRATEGY BE ADOPTED FOR THE DEVELOPMENT OF NAVAL AIRCRAFT?

STUDY REPORT ABSTRACT:

THIS STUDY EXAMINES THE HISTORICAL USES OF THE AIRCRAFT PROTOTYPE IN THE ACQUISITION PROCESS, AND IDENTIFIES CONDITIONS AND EVENTS WHICH WARRANT THE USE OF A PROTOTYPE STRATEGY IN NAVAL AIRCRAFT DEVELOPMENT. PROTOTYPING IS EVALUATED CONSIDERING SERVICE COMPLIANCE WITH DEPARTMENT OF DEFENSE DIRECTIVE 5000.1. PROTOTYPING IS ADDITIONALLY INVESTIGATED AS AN ADJUNCT IN MEETING CURRENT DESIGN TO COST AND LIFE CYCLE COST OBJECTIVES. THE STUDY CONCLUDES THAT COMPETITIVE AIRCRAFT PROTOTYPING CAN PROVIDE SIGNIFICANT RISK REDUCTION IN COST, SCHEDULE, PERFORMANCE AND SOURCE SELECTION. THE STUDY RECOMMENDS THAT THE NAVAL AIR SYSTEMS COMMAND ADOPT AND IMPLEMENT A PROTOTYPE ACQUISITION STRATEGY EMPLOYING A COMPETITIVE, CRITICAL SUBSYSTEMS PROTOTYPE DURING THE VALIDATION AND FULL SCALE DEVELOPMENT PHASES OF FUTURE AIRCRAFT DEVELOPMENT.

subject descriptors: Materiel Acquisition; Design To Cost; Materiel Design & Acquisition; Prototypes; Management Planning; Fly Before Buy; Project Management; Aircraft; Weapon Systems

NAME, RANK, SERVICE	CLASS	DATE
MICHAEL A. PEARCE, CDR., USN	PMC 76-2	D NOV 1976

PROTOTYPING:
A STRATEGY FOR THE ACQUISITION
OF NAVAL AIRCRAFT

Study Project Report

Individual Study Program

Defense Systems Management College

Program Management Course

Class 76-2

by

Michael Alton Pearce
Commander, U.S. Navy

Study Project Advisor
Mr. William Cullin

This study project report represents the views, conclusions and recommendations of the author and does not necessarily reflect the official opinion of the Defense Systems Management College or the Department of Defense.

EXECUTIVE SUMMARY

Former Secretary of Defense McNamara once stated that the overall objectives for logistic management are to:

- Buy only what is needed
- Buy at the lowest sound price
- Reduce Operating Costs

These guidelines are as valid and vital today as they were when first proffered. The desired objectives can be accomplished in the procurement of aircraft weapon systems through a process of competitive, CRITICAL SUBSYSTEMS prototyping.

This study examines the conditions that warrant the use of a prototype strategy in aircraft development and attempts to evaluate the historical uses of the aircraft prototype in the acquisition process. This study assumes that aircraft prototyping will continue to serve a valid military need in areas where prototyping is currently accepted. Additionally, it concludes that the CRITICAL SUBSYSTEMS prototype can provide a significant reduction of risk in the areas of cost, schedule, performance and source selection.

Department of Defense Directive 5000.1 has become one of the strongest guidelines ever published concerning weapons acquisition. It appears that the intent of DOD Directive 5000.1 may not have been fully implemented in the area of aircraft procurement. This paper contends that conditions and events now favor the adoption of a prototype strategy for

the acquisition of naval aircraft. Prototyping is seen as a viable adjunct in meeting the design to cost and life cycle cost objectives expressed by the Department of Defense for weapons acquisition.

A prototype acquisition strategy is advocated and recommended based upon the proven merits of prototype acquisition and the positive effect such a management strategy would have in providing needed guidance to the military and civilian members of the Naval Air Systems Command.

PREFACE

Our ever changing world and the environment of international tensions which create an atmosphere of more frequent and more highly ordered limited wars directly and indirectly involving the United States make it mandatory that we be able to cope with all military contingencies. It is essential that this country develop and maintain a capability for acquisition and production of defense weaponry which is economical and flexible to the point of providing alternative systems for total as well as limited war. Such a capability is within America's personnel and material resources, but it demands an effective as well as efficient means of deciding which of the alternative weapons systems could and should be acquired for the defense arsenal. The thesis of this paper questions whether a process of CRITICAL SUBSYSTEMS prototyping should be adopted as an acquisition strategy for naval aircraft.

Methodology

The historical and objective material for this study was collected through library and records research. Much of the useful current information to be found in the Department of Defense is found in Directives and Instructions. The impact of these Directives and Instructions and the degree to which they are internalized by component organizations, such as the Naval Air Systems Command, can only be obtained through personal interviews. Observations and interviews with both

military officers and civilian officials of the Department of the Navy have been presented as accurately as possible to convey the views of the interviewee. Individual contributions have been listed together as a combined contributing source. These individuals are the formulators, the submitters, and the decision makers who are actively engaged in obtaining defense weaponry for the future. Acting in these capacities, they are responsible executors of the trusts reposed in them.

Justification

The Naval Air Systems Command does not currently employ an acquisition strategy. Available evidence suggests that a prototype acquisition strategy should now be adopted and implemented for the acquisition of naval aircraft. All conditions seem to favor the incorporation of such a policy. Adoption of a Prototype Acquisition Strategy should provide benefits both to the service, to the Department of Defense and to the Government of the United States. Results from prototype aircraft procurement indicate a more maintainable product is produced at a lower life cycle cost.

In order to study the issue of prototype acquisition for naval aircraft, three research questions will be used to bring to light areas for consideration. The questions are:

1. Do the economics of defense spending weigh in favor of a prototype acquisition strategy?

2. What specifically is meant by prototyping and what are the advantages to be obtained from a prototype program?

3. Should a prototype acquisition strategy now be adopted for the development of naval aircraft?

INTRODUCTION

To fulfill its assigned military missions, the U.S. Navy must continually improve the aircraft which perform its air superiority, fighter, attack, anti-submarine warfare and electronic warfare roles. To provide for the acquisition of improved aircraft the Naval Air Systems Command must develop policies which are responsive to operational needs and considerate of national resources. These policies must provide our national leadership with viable alternatives based on hardware demonstrated performance.

With the advent of Department of Defense Directive 5000.1, a serial, development-production cycle (fly before buy) has been adopted as being the most conservative of national resources; particularly where operational urgency has not been critical. Due to determined efforts to reduce risk factors in design and to assure successful development within expected values of performance, schedule and cost; prototyping has been proven extremely effective.

The thesis of this paper is that it is currently more efficient and cost effective to build and fly a prototype aircraft before committing material assets to either a full scale development or a production decision.

Prototypes provide a significant advantage if the technological risks of a design are substantial, if there is uncertainty regarding the advisability of a production requirement, or if there is uncertainty over which of several alternatives is more

desirable for a given mission. The utilization of a prototype does not, of itself, increase either the cost or the duration of an acquisition program.

Historically, a prototype has informed those monitoring and controlling a program that an experimental concept was invalid, or that a technology could not successfully be applied to a military objective, or that a proposed military system did not possess the utility or tactical capability necessary to justify its production. The goals of conservation of scarce economic resources and maximum military performance can both be achieved through prototype aircraft development programs. A prototype provides performance demonstration hardware for a known resource investment.

Chapter I introduces the economic theory governing responsible defense actions and the environment within which present and continued funding requirements must be met. These requirements evolve as a direct result of national defense policy. Chapter II introduces the acquisition environment within which the Program Manager operates. National Defense policy is traced over a decade to show how current acquisition directives evolved and to further expand the implied desires of defense managers. Chapter III discusses prototyping and the rolls it serves in aircraft acquisition. Chapter IV offers comments from leaders of the Naval Air Systems Command and the rationale which suggest that events and circumstances strongly favor implementation of a prototype acquisition strategy for naval aircraft. Chapter V presents the conclusions drawn from this study.

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PROTOTYPING: A STRATEGY FOR THE ACQUISITION OF NAVAL AIRCRAFT

CHAPTER I

THE ECONOMICS OF DEFENSE ACQUISITIONS

The intricacies of modern technology seem to have made present day warfare more science than art, the only factor remaining constant being the knowledge that the implements of defense must ultimately be paid for by the citizenry. Our nation's leaders have come to realize that not only are total resources at the disposal of the nation limited, they are exceedingly difficult to use effectively.

The Allocation of Resources

The law of supply and demand serves as the natural determinant of utility in the private sector, with profit used as a measurement of overall performance and efficiency. Money functions as the common denominator of the private markets. Resources may therefore be readily reduced to quantitative terms.

The mechanics of resource utilization are not nearly this clear-cut in the public sector. When the government purchases goods and services, it allocates resources between these two sectors according to the preferences of its citizens.[1] In actuality, this process reduces private purchasing power. As

[1] David J. Ott and Attiat F. Ott, Federal Budget Policy, (Washington: Brookings Institution, 1965), p. 80.

a result, a portion of the total resources available is channeled into public consumption through appropriations enacted in The Budget of the United States. Because profit is not used as an indicator within the public sector, other means must be found to indicate the adequacy of the outputs.

The fact that governmental activities are organized in accordance with the budget principle means that the objective test of efficiency which is ever present in the market economy is lacking here. There are no tangible and self-enforcing criteria for judging efficiency in the public sector; in fact, there is a great deal of fuzziness in the use of terms in connection with governmental activities.[2]

Despite our affluence, we are a nation of unfilled needs, and both the public and private sectors of our economy can benefit from the application of additional resources to areas such as education, health, and transportation. It was consequently determined that the resources ultimately to be used for defense endeavors must not merely be satisfactorily allocated, but they must be applied to the optimum alternative available. This optimization may take one of two forms:

1. If our need is for a given level of utility or military effectiveness, the alternative (or combination of alternatives) must be found which accomplishes the task at minimum cost.

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[2]Jesse Burkhard, Government Budgeting, (New York: John Wiley and Sons, Inc., 1959), p. 35.

2. When the limit of the budget is constrained, it becomes necessary to find the alternative (or combination of alternatives) which maximizes effectiveness.[3]

In judging which alternative adds the largest increment of utility, a tangible reference is provided by which to measure the efficiency of resource and force utilization. This method of allocating scarce resources among alternative uses has come to be called "system analysis." Since the system analyst deals in problems of what ought to be done, not how it shall be done, greater emphasis is placed on the suitability of the task and the choice of alternatives.[4]

It is easy to see at this point how the economics of defense took a dominant position in the 60's as Secretary of Defense McNamara demanded more reliance on the scientific approaches to management of the public sector. Forced to conform to the budget as a control device of government, defense managers began to make this same budget serve them as an efficient instrument of decision making. By restating the cost of all projects in quantified terms, it became possible to program for future objectives with a projection of total cost and an estimation of whether programs could be accomplished within

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[3]G.H. Fisher, Analytical Support for Defense Planning, Paper P-2650 (Santa Monica: The RAND Corporation, October 1962), p. 3.

[4]Chauncey F. Bell, Cost Effectiveness Analysis As A Management Tool, Paper P-2988 (Santa Monica: The RAND Corporation, October 1964), p. 2.

the limits of the existing appropriation categories and whether the most efficient manner had been chosen to accomplish the required results.

Warfare and Deterrents--
Considerations for Defense Policy

The problems of national security, or defense policy,[5] are increasingly complex. The new concepts of war and strategy, the long lead times, the high operating and support costs of weapons systems, the rapid technological advances, the interaction of military missions, and the magnitude of the potential enemy threat have all contributed to making national security decisions more difficult than ever before.[6] Complexity adds to the burden of study and analysis required for informed decision making, just as the penalties of war itself make attention to the problem necessary as never before.

Today our national security has come to be shaped by the possible challenges which confront us. Looking specifically at enemy threats, three stand out most starkly. These are: all-out war, limited war, and a type of war new to the twentieth century, but highly developed by the communists--the obscure war concealed as internal subversion, or takeover by coup d'etat.

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[5]Refer to Wesley W. Posvor, et al, American Defense Policy, (Baltimore: The Johns Hopkins Press, 1965), p. ixff.

[6]G.H. Fisher, The New OASD (Comptroller) Programming Budgeting, (Santa Monica: The RAND Corporation, March 1962), p. 1.

Limited Resources and Alternative Choices

It rapidly becomes evident that not even a diversified military establishment can afford protection from the total range of inherent dangers. It becomes economically unfeasible to provide funding for the requirements necessary to maintain merely adequate national defense policy in this uncertain era. Much effort was given to the development of this philosophy by Charles J. Hitch and Roland N. McKean in their work, The Economics of Defense in the Nuclear Age. Since this subject has also become the thesis of subsequent works by Hitch and other members of the Rand Corporation,[7] it is sufficient to conclude that:

> No country can defend itself fully against all possible external threats. It takes certain risks with respect to defense for the sake of increasing the domestic welfare of its citizens. It must also compromise between the present and the future. The more actively it promotes defense and welfare at the present time, the more it may (under certain conditions) retard the long-run economic development of the country, by curtailing both private and public investment in the future.[8]

It would seem logical to assume that our forces for all-out war should prove useful in limited war; but it is dangerous to rely too heavily on strategic strike forces to fight a limited war. Deterrent forces must be kept in a state of

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[7]A history of the RAND Corporation is presented in the Editor's Special Report: "Planners of the Pentagon," Business Week, July 13, 1963.

[8]The RAND Corporation, Program Budgeting . . ., ed. David N. Novick, (Washington: Government Printing Office, 1965), p. 2.

highest readiness during periods of limited conflict to maintain this overall retaliatory sanction. An aggressor who can inflict substantial attrition on our strategic striking forces in limited war will gain an advantage regardless of the limited engagement's outcome.[9]

Defense Considerations for Limited War

Considering the preceding statement and the present international situation, there is cause for a more discerning look into the relevance of limited war. "The distinctive feature of limited war is that its outcome does not involve or seem to involve national survival."[10] This is why it is hard to deal with. Does any particular move raise doubts whether any particular encroachment warrants a final showdown? Limited war does not demand that all human and material resources be mobilized against the enemy. It remains a question of morality and expediency, with a feasible strategy based upon a concept of limitations acceptable to national strategy. It is geographically confined and permits economic, social, and political patterns of existence to continue without serious disruption. It does not even demand the utmost in terms of military effort by the forces involved.

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[9]Rockefeller Brothers Fund, Inc. International Security--The Military Aspect, Report II, (Garden City, N.Y.: Doubleday and Co., Inc. 1958), p. 24.

[10]Rockefeller Brothers Fund, Inc., op. cit., p. 23.

Because these attributes constitute the essence of limited war, it is easily misunderstood by those who are neither actively engaged in the struggle nor responsible for the national defense policy. This excerpt from Limited War--The Challenge to American Strategy, clarifies the issue:

> The rational use of military power requires a strategy capable of achieving two primary objectives: (a) the deterrence of such major aggression as would cause total war; (b) the deterrence or defeat of lesser aggressions, which could not appropriately be met except by means short of total war. To deter total war, the United States must convince potential aggressors of two things: first, that it can subject them to destruction so massive that they could not possibly gain any worthwhile objective from a total war; second, that it will employ this kind of retaliation against aggression so threatening as to be equivalent to an attack upon the United States itself. To deter or defeat lesser aggressions the United States must convince potential aggressors--and demonstrate if necessary--that it is willing and able to conduct effective limited warfare. Unless the nation can also wage limited war successfully, communist aggression may force the United States to choose between total war, non-resistance, or ineffective resistance.[11]

Structured in less subtle terms, this means that force is useless, without a resolution to use it. But even without effective weapons systems to counter ever changing threats, national security depends upon the efficient management of the acquisition process and the responsible manner in which scarce resources are allocated and utilized.

Because of the significance of national security, all eyes turn to the Defense Establishment to view the methods of providing for and managing adequate defense. It must be remembered

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[11] Robert E. Osgood, Limited War, The Challenge To American Strategy, (Chicago; University of Chicago Press, 1957,), p.1.

that our fighting force is dependent upon a timely, technologically superior weapon system which is reliable and maintainable during periods of both high and low ordered conflict. To ensure that the best possible weapons systems are developed and deployed, this paper will attempt to determine whether more effective naval aircraft can be obtained through the utilization of a competitive, prototype acquisition strategy.

CHAPTER II

THE ACQUISITION ENVIRONMENT

> "In acquisition, risk is defined as the probability that a planned event will not be attained within cost, schedule, or performance constraints when following a specific course of action."[1]

Weapon system acquisition continues to become more and more a science of dealing in the future. The length of the acquisition process can be controlled to some extent, provided that urgency is recognized at all levels of the defense establishment, by an increase in dollar and manpower resources. Most weapons concepts never leave exploratory or advanced development and fail to gain a firm foothold in the conceptual phase of the weapon system life cycle. Many programs are nursed over a period of years, never to be given necessary production authorization. Once an aircraft acquisition program is commenced to meet a recognized military deficiency, a period of eight to twelve years is usually required to proceed through the Conceptual, Validation, Full Scale Development and Production Phases.

The Program Manager

The program manager has total responsibility for program coordination and to him falls the job of ordering priorities

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[1] AFSCP-800-3 Acquisition Management, A Guide for Program Management, 9 April 1976, P. 8-7.

and selecting alternative courses of action. The Program Manager is authorized to control expenditures appropriated by the Congress and apportioned to his program through the Department of Defense (DOD). He must, above all else, be fully aware of the elements that drive his program and which are standing in its way. Some Program Managers ultimately fail because they have not learned to concentrate their efforts in areas where something can be done, as opposed to those areas over which he has no authority or no control. The Program Manager must design and implement his program master plan while working within the constraints imposed by his service's acquisition strategy. In the current era of centralized DOD control of weapons acquisition this has come to mean that the Program Manager will strive to ensure a certainty of success (reduction of risk) and to ascertain exactly what the government is purchasing through prototype testing (fly before buy) prior to committing additional program dollars (milestone procurement) to a fixed price production contract (design to cost goal).

The manager's primary objective has been one of maintaining program balance between technical performance, cost and schedule. Unfortunately, over the last 10 to 15 years, the emphasis has been placed on meeting delivery schedules rather than cost estimates.[2] Recently, cost has become more equal

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[2]Interview with senior official, Deparmtent of the Navy, August 26, 1976.

than schedule or performance.[3] This is where we are, but how did we arrive and what does it mean?

Early Acquisition Strategy

The managerial risk trade-off among cost, schedule and performance is so interrelated that it is impossible to talk of what is wanted without also specifying when we want it and how much we are willing to pay for it. A change in one parameter will force a change in the others.

During World War II, and to a lesser extent during the Korean War, the requirement to minimize production lead time resulted in the parallel development of weapons systems. Two competing contractors, funded by cost plus fixed fee contracts, developed and produced a production representative prototype. This procedure demanded minimal financial risk on the part of the contractor, allowing him to concentrate on performance and schedule. The aircraft that performed more favorably was immediately put into production. In the Navy's case, Grumman Aerospace Engineering Corporation knew what the Navy wanted and continually produced superior, carrier suitable aircraft.

The 1950's: Eisenhower/Laird. The mechanics of weapons acquisition did not change appreciably during this period. Reliance remained with cost plus fixed fee and cost plus incentive fee contract forms. Late in the 1950's, against a threat of Sputnik induced technological impotence, there was again an

[3]DOD Directive 5000.1 (22 December 1975), Acquisition of Major Defense Systems, p. 2.

effort to foreshorten technological studies and production lead times. Scarce engineering talent could not be wasted in parallel developmental efforts and to reduce schedule delays, a strategy of concurrent development was adopted. Concurrency encourages the overlap of the phases in a weapon system life cycle as a means of integrating the development and production of all systems elements as closely to the same time as the engineering process permits.

The technical and performance success of weapons produced during this period earned high marks while the management of the processes of procurement were clearly unacceptable. ". . . Deficiencies were related to inadequate purchasing methods, information systems, and cost controls, particularly on overhead and manpower costs. Cost estimating came under criticism because of sever underestimates."[4]

Much in the way weapons systems are acquired today can be attributed to the cost overruns and overexpenditures resulting from cost growth over original estimates. This era witnessed the last of the Navy's competitive, parallel development, prototype developmental aircraft. Although neither the F-10-F nor the F-11-F entered production, the Navy's Blue Angels flight demonstration team reconfigured the F-11-F research and development test aircraft, flying them successfully for recruiting purposes for over five years.[5]

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[4]Report of the Commission on Government Procurement (COGP), General Procurement Considerations, January 1974, p. 183.

[5]Interview with senior official, Department of the Navy, August 13, 1976.

The 1960's: Kennedy/McNamara. The McNamara era was to set the baseline for modern procurement philosophy. The systems approach to management was instituted with cost/benefit analysis, systems analysis and exacting applications of cost accounting. Lacking any stimulus or requirement for speed in weapons procurement, and because of a tremendous clamor from both the public sector and the Congress concerning government inefficiency in weapons acquisition; Secretary of Defense McNamara singled out the practice of cost plus contracting as one conducive to contractor inefficiencies. Contracting was rapidly shifted to a fixed price basis, and to an innovative concept known as Total Package Procurement (TPP). Total Package Procurement put contracting risk firmly back on the contractor. The firm that won a developmental contract on a competitive bid would also receive the non-competitive (sole source), fixed price, production contract. The initial justification for TPP was that it would reduce hardware costs, total cost and minimize acquisition time through increased contractor competitiveness. Contracting on a fixed price early in the advanced development area of the conceptual phase (perhaps as much as eight to ten years prior to production), Total Package Procurement forced the contractors to include elements of Integrated Logistical Support and Life Cycle Cost. Total Package Procurement failed. It put too much risk on defense contractors too early in the acquisition cycle. There were too many unknowns.

Although cost overruns were scarcely new, they attracted public awareness more than at any previous time. The public

became conversantly familiar with all aspects of the C5A and F-111 programs. In retrospect, it must be stated that technology was being pushed further than at any previous time in history. Extended developmental processes consumed the critical schedule while numerous design and engineering changes were directed by the government to meet adjustments in threat and mission, in addition to design changes resulting from technology and producability problems.

The 1970's: Nixon/Laird, et al. The 1960's had seen the centralization of decision making power at the office of the Secretary of Defense. Defense Secretary Laird retained the workable portions of his predecessor's policy while returning to proven management methods. He espoused the milestone procurement policy; contracting for the research, development and production phases incrementally. Each used a contract type appropriate to the degree of risk inherent in that portion of the procurement spectrum. This incremental approach required the reporting of program data to a Defense Systems Acquisition Review Council (DSARC)[6] at three critical decision points conforming with the end of the conceptual phase, the validation phase and the full scale development phase of the development life cycle. Provided that all risks have been identified and that alternatives and options have been preserved, the DSARC principles recommend that the Secretary of Defense (SecDef)

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[6]DOD Instruction 5000.2 (21 Jan 1975; Ch. 1, 14 Feb 1975), The Decision Coordination Paper (DCP) and the Defense Systems Acquisition Review Council (DSARC).

authorize the program to proceed through the next phase of the acquisition process. The Decision Coordination Paper (DCP) serves as the contract between the SecDef and the designated Program Manager.

Life Cycle Synopsis. The concept of concurrent development was used extensively during the period when McNamara was the incumbent Secretary of Defense as a means of integrating development and production to accelerate the acquisition process. As a result of the many dis-economics and program problems created during the operation and support phase, procurement philosophy has reverted to a policy which emphasizes "fly before buy." The processes of development and production are clearly separated into distinct, non-overlapping decision periods. Because every acquisition program is different, there are few hard and fast rules. A successful program requires sound, yet innovative judgment.

The development of any new weapon system will include many areas of risk and uncertainty. Mission uncertainty, source selection uncertainty, technical and cost uncertainty, performance and production uncertainty plus the constant threat of technological obsolescence, all make the weapons system acquisition process extremely demanding. Coupled with limited budgets, a rapidly aging force structure, rising costs for real goods and services and for price escalation; the problems resulting from high risk continue to bring attention to the acquisition of new weapons systems.

An Acquisition Philosophy Emerges

> "I can think of no time in recent history when it has been more necessary to do a better job in acquiring major defense systems . . . .[7]

The Department of Defense thus undertook to create and construct an acquisition philosophy which would reduce risk through the elimination of unknowns. This effort has evolved from the work of two men serving as incumbent Deputy Secretary of Defense, David Packard and his successor, William Clements. Although directives continue to be written concerning the weapons acquisition process, Mr. Packard is considered the father of current acquisition philosophy. His thoughts in DOD Directive 5000.1 clearly established policy for the acquisition of major defense systems.[8]

DOD Directive 5000.1 signaled the return to favor of the prototype, used in an aviation context usually refers to ". . . the first complete operating model of an aircraft of a new design which serves as a pattern or guide for subsequently produced models of the same type."[9] (The details of prototyping

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[7]David Packard, "New Policies in Defense Systems Acquisition," address by Deputy Secretary of Defense of the Department of Defense - National Security Industrial Assn (NSIA) briefings, Washington, DC, Aug 11, 1971. Published in the Supplement to the Air Force Policy Letter for Commanders, Oct 1971, p. 26.

[8]"Acquisition of Major Defense Systems," DOD Directive 5000.1, July 13, 1971, p. 1.

[9]"Above and Beyond," The Encyclopedia of Aviation and Space Sciences, New Horizons Publishers, Inc., Chicago, 1968, Vol 0, p. 1.

and the specific definition for this paper will be developed in the succeeding chapter).

As previously stated, The Department of Defense had received severe criticism from both the Congress and the press for a number of years, but during the summer of 1970 DOD was openly attacked and accused of poor management. The causes were not new. One target was the F-111 fighter bomber. Costs had risen from an estimated $5.5 billion for 1,726 aircraft to $7.5 billion for 547 aircraft. The second major target was the C-5 where program costs had risen from $2.9 billion to more than $5 billion for a buy of 120 aircraft.[10]

<u>Fly Before Buy</u>. On July 28, 1970, Secretary of Defense Laird announced a new procurement policy. Contracts would be awarded in stages and a contract for production would not be signed until a system had been thoroughly tested. "We will be checking out the system well in advance, and we will be flying aircraft before we buy the aircraft."[11]

"Fly Before Buy" was not new! It had been used extensively during the 1930's and on through the early 1950's. Most experts agree that it fell into disuse during the "missile gap" as the U.S. attempted to bring technology into hardware more rapidly. A second factor in the shift away from prototyping was the extensive use of computer systems which made Total Package

[10] New York Times, "New Pentagon Contract Policy Seeks To Avert Cost Overruns," June 10, 1970, p. 1-2.

[11] New York Times, "Future Defense Contracts To Be Awarded in Stages," July 28, 1970, p. 1.

Procurement appear as a most suitable method to achieve both cost and schedule savings. It was presumed that through computerized data processing fixed price contracting could be specified for the entire production phase even before development work had begun.[12]

Design to Cost. If the cost of developing and acquiring major aircraft systems had been rising at a rate consistent with inflation, there might have been little cause for alarm. Unfortunately, costs for the 1962 through 1972 period rose nearly 300 percent while industrial commodities increased only 22 percent.[13] Thus, a second modern acquisition philosophy emerged. Dr. John S. Foster, Jr., Director of Defense Research and Engineering, Office of Secretary of Defense stated that:

> . . . DOD must establish a price per item copy that is compatible with both the minimum required military performance and with what we can afford to pay for the quality number of products we need. Products that are just inexpensive are not acceptable. Military needs must be met or we will not buy the equipment. To accomplish this, we are willing to pay more in time and dollars in the R&D phase to assure achieving the desired unit production price and support costs . . . .[14]

While this statement by Dr. Foster introduces design to cost, it also included one other reality which was, and still

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[12]Albert W. Blackburn, "Soaring Defense Costs....Blame It On The System," The New York Times, April 1, 1973, p. 3.

[13]Project ACE--Findings and Action Plans, Air Force Systems Command, Oct. 5, 1973, p. 1.

[14]Jacques S. Gansler, "Acquisition Objective Changes From One of Sophistication to Reliability at Lower Cost," Defense Management Journal, Vol. 9, No. 3, July 1973, p. 4.

is, overlooked. This fact is that a lack of money and effort in the early conceptual phase (Research, 6.1 funding sources; and Exploratory Development, 6.2 funding sources), commonly known as "front end neglect" predictably results in cost problems in both producability and operational support. The design to cost concept then is to be ". . . achieved by practical trade-offs between operational capability, performance, cost and schedule. Cost, as a key design parameter, is addressed on a continuing basis and as an inherent part of the development and production process."[15]

The design to cost philosophy also strongly favors the system prototype. Prototyping is an acknowledged method of reducing production risk and increasing the reliability of life cycle cost estimates.[16] These objectives are both vital to the Department of Defense whose primary purpose it is to assure that this nation can fulfill its commitments, preserve its interests and maintain peace and world security.

Design to Life Cycle Cost. The design to (unit) cost concept has matured into a design to Life Cycle Cost (LCC). The basic thrust is still a shift away from achieving the highest possible performance and toward achievement of the best possible defense posture for the resources invested. It has been prudent to revise the design to unit cost goal upward in cases

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[15] "Design to Cost," DOD Directive 5000.28, May 23, 1975, p.2.

[16] Robert L. Perry, "A Prototype Strategy For Aircraft Development", The Rand Corporation, Santa Monica, Cal., Memorandum RM-5597-PR, April 1968, p. V.

where operating and support costs would be reduced.[17] The goal is stated as quality equipment produced at a price allowed by budget constraints. Competitive prototyping, with a "flyoff" is envisioned as the method to attain this objective. (Competitive prototyping can be thought of as a form of insurance in the budget, schedule slack, or parallel approaches to the same problem. In terms of Risk management, it is no more wasteful than life insurance premiums when the insured fails to die at a young age).

The aerospace industry has voiced some concern about design to cost and life cycle cost philosophy. This concern is related to a product for which there is but one customer. The government sets the performance, can shift requirements and buy in limited volumes. Care must be taken in choosing only those weapons systems which are necessary and affordable; however, a premature commitment to projections of what will be necessary and affordable can only be avoided with the use of competitive prototype programs which eliminate minimal performance systems. Industry must be allowed to retain the latitude to propose early conceptual changes which reduce life cycle costs.

Current Acquisition Truths

Research in this area has shown that certain underlying truths both guide and govern the acquisition process. Some of

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[17] Memorandum from the Deputy Secretary of Defense to the Service Secretaries, regarding Reduction of Outyear Operating and Support (O&S) Costs, Feb 28, 1976.

these have been previously stated, some have only been alluded to. A summary is provided here for further reference:

- Each year less of the DOD budget is available for weapons acquisition due to inflation and the fixed overhead costs of military manpower

- Military budgets have come under increased Congressional scrutiny due to continued cost overruns in weapons acquisition

- Weapons sytems continue to become more costly to replace

- As aircraft systems become more sophisticated, the risks inherent in technological development and production increase

- Intensely automated, high performance aircraft have become increasingly expensive to operate and support

- Design and engineering changes, whether for increased operational capability or to correct deficiencies, have multiplicative cost impacts not only in production but in operation and support areas

- As production, operating and support costs grow, research, development, and acquisition costs have become proportionally smaller increments in the total life cycle cost

- While schedule can still drive an acquisition program, modern management trends have made cost of greater concern than performance and schedule risks

Emphasis then is clearly focused on the area of cost control. Perhaps with good reason. A 1970 Government Accounting Office ". . . study of 57 major systems revealed 38 systems with an estimate of 30 percent increase from the point of contract award (50 percent from planning estimates)--$62.8 billion versus the original $49 billion."[18] It is believed that this is an area where competitive, developmental prototyping will provide major benefit.

The Case Against Time Delays

There are those in the DOD and in industry who hold reservations regarding the increased emphasis on cost control. There is reason to fear that it is possible to approach a point where less rather than more is received in return on the defense dollar. Arguments state that delays due to program stretches, prototype developments and increased operational testing create risks in and of their own. Relaxed schedules can invite additional engineering changes and modifications. Program stretches increase costs due to inflation as well as contractor overload charges. Key personnel departures affect both the government

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[18]Report of the Commission on Government Procurement, op. cit., p. 182.

and contractor with a loss of corporate money. A program faces an increasing probability of being cancelled the longer it proceeds without a tangible return on investment. A desire to be right has many subtle effects on continuously delayed decisions. These items could be used effectively in developing a case against prototyping. Why then, is prototyping in such demand?

CHAPTER III

PROTOTYPING - AN ACQUISITION AID

> "A need results in an idea that is converted into a working model; the model is tested, changes are made, new tests are conducted and the cycle is repeated until a useful product is developed that fulfills the need . . ."[1]

Seldom has one word held as many different connotations and implications as prototyping. The word prototype has been used in over 50 descriptive titles. It has been tied to phases of the developmental process. It has been used to describe the purpose for which hardware was fabricated. It has been constrained by modifiers to express dollar limitations and to define the scope of an effort.

Prototyping Categories and Objectives

One method of understanding the nomenclature associated with prototypes is to look at the categories that prototypes have been placed in and the objectives which they serve. One category is that of generic or general purpose names given to models and mockups during Research and Development (R&D). Beginning with the simplest, the list would read: breadboard, brassboard, demonstrator, technology demonstrator, sub-system prototype and system prototype. Prototypes can also be categorized through time as derived from R&D funding categories:

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[1]USAF Prototyping Study, op. cit., Appendix I-1.

exploratory development (6.2), advanced development (6.3), and engineering development (6.4). Prototypes have taken their names from the phases of the acquisition cycle; conceptual model, validation prototype, full scale development prototype, pre-production and production prototypes. In summary, it can be concluded that:

> A "prototype", by definition, may involve a complete system, subsystem, component, or other hardware, and may be contracted for at varying points within the development spectrum. The effort being performed may represent "exploratory development," "advanced development," and the hardware may be categorized as an "engineering," "development," "pre-production" or other prototype. The statement of work may contain specific requirements or may contain only "design goals" or a contractor's "best efforts." Simple or multiple awards may be made and a particular award may be the result of competition or sole source.[2]

Late in 1971 the Navy was asked to respond to an Office of the Secretary of Defense(OSD) prototyping initiative in which a prototype matrix was depicted.[3] This prototype matrix still appears in the Department of the Navy RDT&E Management Guide and subdivides a prototype by:

EXTENT - Complete System, "Barebones" Model, Hybrid, Subsystems, or Component

APPROACH - Complementary, Competitive, or Single Source

PURPOSE - Experimental, Developmental, or Production

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[2]U.S. Air Force Prototype Study (AD5196.3) Department of the Air Force, ASD, AFSC, Wright-Patterson AFB, Ohio, 14 March 1972, p. 3-12.

[3]OSD Memo "Research and Development in the Department of Defense...A Management Overview," Nov 1971.

The three principle categories of prototypes and their purposes are:

- Experimental: To demonstrate technological feasibility
- Developmental: To gain sufficient confidence before committing a system to full scale development.
- Production: To prove out the system, tools and methods prior to quantity production[4]

During 1972, the Navy addressed the longer range aspects of prototyping in the Navy Weapon System Acquisition Process with high level discussions of the procedures and process necessary to establish prototyping.[5] It was clear from the outset that the Navy hierarchy, too, was confused by prototype terminology.[6] The terminology problem has not been of major consequence concerning the subject, ". . . the Navy has given little more than 'lip service' to the concept of prototyping."[7]

For consistency in this paper, the term "Prototype" should convey to the reader the concept of a full sized, CRITICAL subsystems aircraft (i.e., airframe, engine, hydraulic, electrical, flight control, crew safety, etc.) utilized to obtain design, cost, schedule, and performance confidence in preparation for

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[4]Dept of the Navy RDT&E Management Guide, NAVSO-P-2457 (Rev 1-75), Asst Sec of Navy (R&D) Washington, DC, 24 Dec 74, p.2-20

[5]Letter from Chief of Naval Operations to Chief of Naval Material concerning "The Navy Prototyping Program," dated 2 July 1972, p. 1-2.

[6]Ibid, p.1.

[7]Interview with senior official, Department of the Navy, July 15, 1976.

DSARC II. The same prototype must be capable of meeting both program Developmental Testing and Operational Testing (DT/OT) requirements, and of providing configuration information from which to plan for operational and logistics support prior to DSARC III. The DSARC process provides for incremental investment and control in order to determine that unnecessary risk has been identified and reduced prior to an increase in dollar investment. While this is the specific application of prototype used in this study, it should be noted that in simplest terms a prototype is ". . . a tool for lessening technological uncertainty."[8]

Risk and Uncertainty

The acquisition process is a methodology used to ensure risk reduction and/or elimination. Once a threat is identified, mission uncertainty must be resolved, and, provided that a decision can be reached that this is an area where scarce resources should be committed, an Operational Requirement (OR) is derived. If the threat is perceived to be expanding rapidly, provisions for growth must be included in the OR. Uncertainty must first be reduced in the proper time-phasing of development and production and in the selection of the production source. Inherent in the process of development and production are the risks attributed to unknowns of cost, schedule and performance.

[8]"A Prototype Strategy for Aircraft Development", by Robert L. Perry, Memorandum RM-5597-PR, The Rand Corporation, Santa Monica, April 1968, p. 1.

Although many aircraft weapon systems have been procured through a process of "Contract Definition," where risk is the contractor's burden as he produces from approved design specifications, the most capable and "successful" weapon systems have originated from prototype procurement programs.[9] In a prototype procurement a small quantity of aircraft are produced for purposes of evaluating and testing both the design concept and the hardware form, fit and function prior to a final decision for production. The desired outcomes of pre-production testing are the identification of design oversight, the knowledge of performance shortfalls, and the quantification of costs associated with specific technology applications and production methods. In today's environment of scarce resources, prototyping provides the earliest answers to these areas of known unknowns.[10] Prototyping additionally allows the decision maker to make informed trade-off judgments whenever cost, schedule or performance thresholds are approached.[11]

While many things can be foretold of an aircraft weapon system while it is still in paper design stages, the full impact of scaling, integration and compatability cannot be adequately identified. Early testing on full scale, prototype hardware provides the answers to questions which would otherwise remain until production tooling and production methods

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[9]Examples are B-47, F-105, KC-135, P-3.

[10]Perry, Ibid, p. V.

[11]DOD Directive 5000.1, p. 5.

had to be modified. "Production costs are usually many times greater than developmental costs and involve commitments for a wide variety of long lead items. Changes in the later stages of development are likely to have a substantial impact on production commitments. Delaying commitments for production until successful development has been fully demonstrated is likely to have a large payoff in total program cost."[12]

The significance of production change is emphasized here because there is an offshoot to the "fly before buy" school of thought that favor a Low Rate Initial Production (LRIP) as a form of prototyping to be utilized to correct design deficiency and producability problems. A pre-production or LRIP aircraft cannot, in fact, be considered a prototype at all because it is produced on production "hard tooling."[13]

A true prototype is produced on "soft tooling" and will not require that the production line run, once started, be shut down while DT/OT III testing is conducted. Once the production line is readied, there is a constant pressure to commence LRIP while awaiting test data. Costs rapidly mount as the labor force and plant equipment stand idle and material costs increase. Even when production subsequently is authorized, few changes can be incorporated on early aircraft. Different configurations begin to create different lots within the same type/model/series

[12] Introduction to Military Program Management, DSMS reprint of LMI report 69-28, March 1971, p. 13.

[13] Perry, op. cit., p. 5.

causing retrofit decisions and resulting in reduced commonality of spares, ground support equipment, technical data, and the remainder of the nine logistic support categories. Although LRIP allows the earliest delivery of hardware to meet Initial Operational Capability (IOC) dates, it is a procedure closely related to concurrency. Although time is compressed, historical data shows that performance has not been met, cost data has not been validated and considerable redesign on both mission and engineering redesign are required. Even with the DSARC Process specifically designed to guard against concurrency, LRIP is tricky business and should never be considered as an alternative to the prototype acquisition for risk reduction. LRIP involves a commitment to substantial program costs which may be wasteful in the event of program cancellation or redirection. LRIP has been used successfully in selected cases where DSARC III has passed the program into the production phase and service procurement funding is not yet available in the dollar amount required.

Prototype Procurement

Prototype procurement then refers to the development of a small quantity of semi-hand constructed, (soft tooled) aircraft built specifically for the purpose of evaluating the design concept and the testing of full scale hardware prior to a final production decision. Prototype testing results are essential to informed decision making. Modern aircraft are more than the single purpose weapons of past eras. Today's aircraft

combine complex technology in many critical subsystems--each of which impact specifically at various interface boundaries. The integration effort required to effect the joining of subsystems in an area of minimum size, with minimum weight for maximum performance during a given time and for a specified cost are again complicated as sophisticated weaponry and target acquisition systems are added to provide the aircraft with primary, secondary and even tertiary mission capabilities. The magnitude of these interface problems is further compounded by system redundancy, variable geometry structures and even the lack of surface area in which to implant antennae.

Early Experience. Looking at experience gained during the 1950's, it can be seen that even using the systems approach it was not possible to obtain sufficient data on, or to understand and control a system's design configuration.

Of the six fighters developed by the Air Force during the 1950's, four ended up with completely different engines than those originally programmed, three with different electronic systems than envisioned, five with airframes extensively modified from the initial design and three with substantially different operational missions. Only the F-106 proceeded through development and production with the same mission and configuration. Unfortunately, the F-106 was delivered in much smaller quantity than planned, at much higher cost, and five years later than scheduled because the F-101, designed for a different role, proved to be a better interceptor than the F-106.[14]

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[14] Perry, op. cit., p. 38.

While there have been successful non-prototype development programs (F-4, F-5), in most cases where a prototype procurement process was not used, systems were obsolete when delivered, not ideally suited to the mission or badly over cost thresholds.[15] As pointed out in Chapter I, the U.S. can no longer afford such inefficient resource utilization.

Opposition to Prototyping. It has been assumed and asserted that prototype acquisition is both more costly and time consuming than conventional development. These arguments are successfully refuted in a series of Rand Corporation studies begun in 1971. Analysis does not support those objectors for systems which involve large dollar commitments or which are attempting to rapidly advance the technological state-of-the-art.

> In the end, there is no evidence that the total program cost of a fighter acquisition program is greater when prototypes are used than when they are not, or that the time from start of development to first operational availability is greater. Differences, if they exist at all, seem to be so small as to be indistinguishable when entire programs are considered.[16]

There were periods in our history when prototypes were not used. While aircraft remained relatively simple during the 1940's and early 1950's, the Navy's mission for aircraft remained essentially stable. Contractors would design and build what they thought the Navy should have for the next generation

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[15] LTCOL Edward P. Miller, Air War College, Air University Report 5349, "Current Systems Acquisition Realities," April 1974, p. 35,36,37.

[16] Perry, op. cit., p. 40.

aircraft. As the Navy's roles and missions began to expand and as structures and subsystems became more complex, defense contractors could no longer afford to design, build and compete their aircraft within the constraints of corporate Independent Research and Development funds.[17]

An old, accepted way of doing business had become outmoded with the increased cost and complexity of aircraft weapon systems. While the term "fly before buy" has an appealing ring and promise of added benefit, the fact remains that the prototype acquisition process is neither new nor is it unique to the U.S. Prototyping has been a standard concept in both France and Russian military aircraft production for over 30 years.

Prototyping's Dubious Success. Examples of the success of the prototype process are not always readily evident when looking at the operational inventories of the military components. Prototypes have traditionally been used to prove that a technology is "at hand" and could be incorporated for a military application. From these advanced technology prototypes has come a connotation of "Go,No-Go," and there are by far more failures than successes. In spite of this negative validation aspect, the fact remains that the prototype did prove that a concept could not be converted to a cost-effective military application and provided a conclusion recommending program cancellation. This, by definition, proves the prototype a success

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[17]Interview with senior official, Department of the Navy, August 27, 1976.

in eliminating costly and ineffective systems. In many cases, the decision to terminate a prototype effort resulted in an extremely successful follow-on or successor aircraft. Examples include the Navy's F-111B and SAC's B-45. Proper testing and evaluation of prototype performance led to program cancellation, yet the technology and systems developed for the F-111B were transferred to the F-14. It is almost a certainty that had the B-45 been produced, the highly successful B-47 would never have been developed. Notwithstanding, a feeling exists in the aerospace and defense committees that, while there are advantages to technology and developmental prototyping, when you know what you want, a prototype program is a good way to get the program cancelled.

Design to Cost. Even stronger than the "fly before buy" emphasis of DOD Directive 5000.1, is the realization that cost estimates have never proven to be reasonable or accurate in defining aircraft costs. In many cases, this is because the government changes the scope of the contract, directs redesign or reduces the production buy. In others, it is due to poor planning, lack of knowledge or unidentified risks. Regardless of the reasons, minimum cost with technical risk avoidance can be obtained through developmental prototyping and intensive pre-production testing, rather than relying heavily on paper design analysis.[18]

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[18] Arthur J. Alexander, "Design to Price From the Perspective of the United States, France, and the Soviet Union," AD-768031, Rand Corp, Santa Monica, CA., February 1973, p. 9.

Once hardware is available, production, operational and support costs become infinitely more clear. This single, simple fact is probably one of the most startling revelations of the 1960's. The design to cost goal as defined by DOD Directive 5000.28 is a specific cost number, ". . . based upon a specified production quantity and rate, established early during system development as a management objective and a design parameter for subsequent phases of the acquisition cycle."[19] The stated objective of Design to Cost is: "To establish cost as a parameter equal in importance with technical requirements and schedules throughout the design, development, production, and operation of weapon systems, subsystems and components. To establish cost elements as management goals for acquisition managers and contractors to achieve the best balance between life cycle cost, acceptable performance and schedule."[20]

By establishing cost as a discipline and design parameter during the acquisition phases, and by requiring the establishment of cost elements for development, production, operation, and support (the weapon system life cycle), the Department of Defense has made it possible to consider "trade offs between system capability, cost and schedules . . . to insure that the systems developed will have the lowest life cycle cost consistent with schedule and performance requirements."[21]

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[19]DOD Directive 5000.28, p. 2.

[20]Ibid.

[21]Ibid., p. 3.

Since these costs are closely checked at the end of the conceptual, validation and full scale development phases by the DSARC process, the verification of design, maintenance, and logistic support concepts through hardware proofing becomes a necessity during validation and full scale development. The 1970's then, have seen a resurgence of the prototype with good cause. Elmer B. Staats, in testimony before a Senate subcommittee on anti-trust and monopoly, stated that the Government Accounting Office (GAO) recommended prototyping for the following reasons:

1. Competition would result in better performance, price and delivery.

2. Hardware could be compared before a production go-ahead signal is given.

3. Cost overruns would diminish because contracters would have visible products on which to predict costs.

4. DOD would have maximum flexibility in the face of changing threats and accelerated technology.[22]

Competitive Prototype. The remarks of the Comptroller General bring one more important fact to bear on the case for the prototype. The leaders and managers of this nation have a pervasive and well founded confidence in the strength of the American free enterprise system. Regardless of philosophical differences, they are united in the belief that competition

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[22]U.S. Congress Joint Economic Committee Hearings. Economics of Military Procurement. Washington: U.S. Govt. Printing Office, 1968, Part I, p. 368.

will provide a better product. Wherever prototyping has been found to be effective, the award of parallel development contracts has produced even more significant results. This realization is also held outside the Free World. The Soviet aviation development process may be described as parallel prototype (if not competitive), in which several designs are independently carried into developmental testing. Following extensive testing, one is selected for quantity production.

In U.S. aircraft development the competitive, parallel development process has recently been very rewarding. The Air Force let competitive prototype contracts on the AX, combat support aircraft. The A-10 has been exceptionally well received. In a recent competitive fighter prototype fly-off the Air Force selected the F-16, while the Navy has modified the F-17 and redesignated it the F-18.

Competitive prototyping was earlier compared to insurance. Protection is provided against contract buy-in, schedule slippage, and the insurance inherent in competition--several optimized approaches to the same problem. The incentive to sound developmental prototyping lies in the follow-on production contract for the most responsive contractor. Even after the production award the insurance remains in the form of a qualified back-up contractor capable of fulfilling military needs. In this process the country's industrial base is also preserved. Our country badly needs to encourage this capacity in the present environment of fewer competing defense contractors.

Could one contractor do better in the development of an aircraft weapon system with the funds which must of necessity be split between two competitive prototype contractors? Rand analysis says, No!

"In prototype programs, there are abundant indicators that a policy of austerity in the assignment of resources pays substantial dividends, not only in program costs, but also in focusing attention on crucial uncertainties that should be resolved before production commitments can sensibly be made. . . . . Including a prototype phase does not necessarily make the cost or duration of a development program significantly greater than the cost or duration of a more conventional development production program."[23] The prototype program then is a distinct advantage if austerity in the expenditure of resources is a guiding principle. In terms of risk management, the odds strongly favor a competitive prototyping policy.

A Case For Earlier Prototyping

As has been seen from the economics of defense, the environment has made defense managers less and less willing to accept production risks on defense contracts. An incremental acquisition strategy has evolved which supports the system engineering approach. A series of three major developmental and operational testing periods is required as part of the fly before buy philosophy to reduce both developmental and production, as well as operational and support risks. The configu-

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[23] Perry, Rand Report, P. VI.

ration of the prototype must remain unfrozen so that changes from both the contractor flight testing and the government's developmental and operational testing can be incorporated.

The sooner that development changes can be incorporated and the baseline configuration finalized, the less impact those changes will have on production aircraft. The early finalization of design and implementation of configuration control for the weapon system will enable earlier definitization of all support consideration. Drawings and manuals (technical data), support and test equipment, supply support, facilities, training and other logistic support requirements must all be changed when changes are implemented to the aircraft. Fewer hardware changes result in a considerable dollar savings in logistic support areas. Prototyping permits the earliest testing and with proper management should provide the earliest production configuration.

In summary, the following advantages are realized by using a competitive, CRITICAL subsystems prototype program beginning early in the validation phase.

- Reduces technological risk and uncertainty
- Enables the decision maker to identify and judge trade-offs in cost/schedule/performance
- Permits changes, if essential, to be incorporated early
- Identifies systems interfaces and impacts
- Cost effectiveness in terms of funding constraints

- Provides most realistic cost information

- Permits earliest government testing

- Ensures the earliest visibility for Integrated Logistic Support requirements

- Ensures life cycle costs are identified

- Ensures contractors are more competitive

- Provides the government with greater leverage for the negotiation of both prototype and production contracts

- Affords the Defense Department a greater flexibility to respond to changing threats and accelerated technology

- Eliminates risk for production source selection

- Requires less retooling and production retrofit expense

- Provides a backup to prime contractor

- Provides essential information needed to satisfy DSARC II and III decisions

In the simplest of terms, a prototype program allows the Program Manager to maintain a Program Balance--the ability to make a trade-off in risk from among Cost, Schedule and Performance. In the same manner, it allows the Acquisition Managers at higher levels to maintain a Balance of Programs--the ability

to allocate scarce resources between programs on the basis of greatest return at the least risk.

If prototyping is so good, why hasn't it had greater use? There is always a tendency to do things in the manner which is easier and most accepted. Prototyping efforts, if not properly managed, can be both more costly and more time consuming. Prototyping also requires greater managerial attention on the part of the contractor and the program office. Much more discipline is called for in the area of configuration management. Prototyping does result in more work, but it can do the job in a more efficient manner. Competitive prototyping, by definition, is more costly, however, considering that the validation phase accounts for only three percent of the total life cycle cost, it is worthwhile to make an investment early in order to reduce subsequent operating and support costs.

CHAPTER IV

PROTOTYPING AND THE NAVAL AIR SYSTEMS COMMAND

> The hottest places in Hell are reserved for those who in a time of moral crisis refuse to take a stand.
>
> G. George Ostrom

During the preparation for this study, an investigation was conducted in order to determine a rationale for How and When the Navy acquires its aircraft weapon systems. Three observations were apparent. First, there is no systematic approach to aircraft development. It just happens; based on the timing of a deficiency (need) perceived from a verified enemy capability, provided that dollars can be found within the service budget. All Navy acquisition programs compete for the same limited funding during a fiscal year. The Navy's budget for any given year cannot sustain two new aircraft starts. If there should be two starts in a year, one program would be forced to hold several years or cancel. "Unrealistic as it may seem, the user generated IOC date has been the prime driver for Naval Air Systems Command (NASC) projects until recently."[1]

Second, the vehicle which could, and in all probability should, be used to communicate policy, priorities and an acquisition strategy throughout NASC is readily available. The

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[1]Interview with senior official, Department of the Navy, August 26, 1976.

Naval Aviation Plan, published annually, is capable of performing this function.

Third, unless the individual worker within NASC is close to the top of the organization, it is very difficult to determine "which way the wind blows." It is believed that an organization possessing the resources and telents which the Naval Air Systems Command has could be a great deal more efficient and effective if the "game plan" as well as the short, long, and midrange priorities were readily available.

Acquisition - Past and Present

An interview with a senior official of the Naval Air Systems Command, confirmed that NAVAIR did not operate with an acquisition strategy. He was asked whether he felt he could get more done through his knowledge of the environment and his personal and positional power as the Navy's acquisitional manager. "No, there are just too many constraints for that; OPNAV, the Secretariat, OSD, and the Congress."[2] Asked for his views on the use of aircraft prototypes for the acquisition of new weapon systems, he explained, "We have two aircraft in prototype work now, the F-18 and the CH-53E. We use to types--the Advanced Technology prototype* and the standard prototype, like we used in World War II, before going into production.

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[2]Ibid.

*Advanced Technology Prototype - an experimental prototype, not built to scale, which is used in high technology risk areas to advance the state of the art.

The F-14, on the other hand, went directly from Request for Proposal (RFP) to production in 20 months. While the F-14 performance is very good, there are reliability problems. I believe we should conduct our programs now like the F-18. That program works because of Operational Test and Evaluation--OT&E prior to production."[3]

These remarks were amplified by another senior NASC official. "Twenty years ago, we had more concurrent programs. Several aircraft would be brought along, and one chosen. In several cases, the P-4M for an example, was in production; the P-2V was phased in--both were built and then the P-4M was cut. . . ."[4] In recent years the Navy has been strictly reactive--new aircraft are started on guidance or mandate . . . ."[5] "It has been the case that the IOC drives. In the development of naval aircraft, timing has been all important."[6]

An Opportunity for Change

During discussions with the leadership of the Naval Air Systems Command several comments made a very convincing argument in support of the premise that we can and should do better--and that prototyping is a recognized means of getting the best

[3]Ibid.

[4]Ibid.

[5]Ibid.

[6]Ibid.

product at the most favorable cost. "The philosophy at the present is that it takes time to develop an aircraft. Although IOC has driven previously, today the most important items in order are cost and performance. If we can't meet performance requirements, we will look at what it takes. In the case of the CH-53E, we have just slipped the schedule nine months because, under current technology, the rotor shaft is only good for 225 hours. We hav got to do it right the first time; we can't afford not to."[7]

"It's time for a common sense approach. We've got to look at cost more sensibly! We are at peace. We need to stop buying ECP's [Engineering Change Proposals] which amount to a new program while we're in production . . . ."[8] This is the problem with the F-14--too many compatibility changes."[9] "Yes, we should have an acquisition strategy, but it should not come from the service or from DOD; it should come from the CNO Requirements Group."[10]

Comments obtained from another source also conveyed the same positive thrust. "From my experience, hardware is much more convincing than brochuremanship when it comes to selling an

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[7]Ibid.

[8]Ibid.

[9]Ibid.

[10]Ibid.

aircraft . . . ."[11] "We need early confidence in cost; cost and schedule. This is extremely important for logistic planning and in software areas . . . ."[12] "Yes, an acquisition policy today is highly desirable--there is a caviat, however. This is the fact that it will cost more in money and time if you are being driven by the IOC. If you have time and don't need a replacement aircraft, the ideal is a competitive, parallel prototype."[13]

The Time is Now

The precursors of change strongly indicate that the time has come to implement an acquisition strategy for the development of naval aircraft. Although one interviewee raised a valid point--that of policy guidance at the level of the CNO Requirements Group--it is believed that policy guidance and a Naval Air Systems Command acquisition strategy are independent events. While CNO guidance would assist NASC in determining some elements of its strategy, the factors mitigating for an acquisition strategy will demonstrate this independent relationship and will, therefore, be reviewed.

Defense Economics. Chapter I portrays a need for economy. There is an ever increasing requirement to use scarce resources allocated to defense procurement more effectively. The real hardware purchasing power of the DOD (Total Obligational

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[11] Ibid.

[12] Ibid.

[13] Ibid.

Authority) has shown a continuous decline from FY 1967 through FY 1975, when defense buying power reached its lowest level since 1951. "Even with the increase in FY 1976 and FY 1977, the FY 1977 program will still be well below the levels of the peacetime 1950's and 1960's."[14]

Proven Prototype Advantages. Prototype programs have proven their worth and usefulness in reducing risk, identifying cost and verifying all aspects of producability. The prototype has been a major factor in providing service managers with the assurance of being able to achieve cost goals. The design to unit production cost goal is being replaced with increased emphasis on design to life cycle cost criteria.

The DSARC Process. The Defense Systems Acquisition Review Council (DSARC) was originally establishedto "... serve as an advisory body to the Secretary of Defense on the acquisition of major defense system programs and related policies and to provide him with supporting information and recommendations . . . ."[15] More and more these reviews prior to authorization to proceed, are requiring the type of information which can be provided only by a prototype program. During the DSARC II review prior to a full-scale development decision, the DSARC principles are to determine that:

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[14] Annual Defense Department Report, FY 1977, Secretary of Defense, Donald H. Rumsfeld, p. 21.

[15] DOD Directive 5000.26 Defense Systems Acquisition Review Council, Jan 21, 1975, p. 2.

The Defense System still satisfies the military need and the requirements projects relate to the mission, the threat, and anticipated resources.

System tradeoffs have produced a proper balance between cost, schedule and performance, including reliability and maintainability as well as fallback positions.

Quantity, resource and schedule estimates are realistic and acceptable. Relative cost estimates of support and operations have been evaluated over the life cycle; and estimates for both acquisition and support have been validated.

Major uncertainties and risks have been reduced to acceptable levels and methods are identified to resolve uncertainties and risks.

The proposed system is cost effective compared with competing alternatives.[16]

Later, during DSARC III review leading to the production/deployment decision, heavy emphasis falls upon DSARC II requirements, plus:

Production and logistic support, facilities and maintenance request identification.

Test results based upon Development Tests (DT) and Initial Operational Test & Evaluation (IOT&E).[17]

Prototype Activity in Other DOD Components. With cost being the most critical of program risks, and because DOD

[16]Ibid, p. 5-6.

[17]Ibid, p. 6-7.

Directive 5000.1 refers to the use of prototyping to determine program costs,[18] the Army and Air Force have utilized competitive prototype programs with success during the last five years.

The Air Force selected the A-10 from the A9/A-10 prototype competition (AX-close air support mission) and the F-17 from the F-16/F-17 prototype competition. The Air Force is currently close to a contract decision on the Advanced* Cargo/Tanker Aircraft (ACTA will replace the KC-135) and the Advanced* Medium STOL (AMST will replace the C-130).

The Army selected their original Scout helicopter from Hughes Aircraft Corporation and Bell prototypes and will select their Utility Tactical Transport Aircraft System (UTTAS) from competing Boeing and Sikorsky models. The Army is also conducting prototype competitive for the Advanced* Attack Helicopter (AAH) and the Advanced* Scout Helicopter (ASH).

While it is not correct to infer that the Navy should always follow the lead of sister services or that the Army and Air Force are always correct; prototyping, since the advent of DOD Directive 5000.1, is the way business is being done in the Washington Arena.

Navy Prototype Activity. To what degree is the Navy involved in prototyping? The Navy has used prototype testing to validate selected system components, but has not used a

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[18]DOD Directive 5000.1, op. cit., p. 6.

*Both the Air Force and the Army use the word ADVANCED to connote 1980 Technology applications.

developmental prototype for a Navy aircraft[19] since the F-4 vs F8U-3 flyoff. Advanced technology prototyping is being done on the XC-142 tiltwing V/STOL built by Vought/Ryan/Hiller. "Currently there is no basic plan within the Department of the Navy on how to accomplish prototyping for naval aircraft--with exception of the thrust augmented wing XFU-12A, which has proceeded from the conceptual phase direct to Engineering [Full Scale] Development. The reason for this is that all recent Naval aircraft are extensions of C/TOL (Conventional Takeoff and Landing) technology. With the advent of V/STOL, the Navy is finding an entirely new technology era."[20]

Clearly it would seem that the Navy has no immediate plans to use prototyping for other than advanced technology. This is confirmed by the Navy RDT&E Management Guide which states, "It is not uncommon for people to equate 'RDT&E' with the development of hardware, a view which is as limited as it is erroneous. The 'product' or 'output' which justifies RDT&E effort is an operational capability . . . . This point must be emphasized. The objective of RDT&E is operational capability, not hardware per se."[21]

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[19] A possible exception could be noted in procurement of Light Armed Recon Aircraft which NASC developed for the Marine Corps from 1964-67 through flyoff between the North American OV-10A and Convair "Charger." See Perry, p. 16-26.

[20] Interview with senior official, Department of the Navy, July 15, 1976.

[21] Department of the Navy RDT&E Management Guide, NAVSO P-2457 (Rev 1-75), The Asst Sec of the Navy (Research and Development) Washington: 1 Jan 1975, p. 2-7.

The Current Aircraft Mix. The Navy, in terms of the current operational inventory and current aircraft contracts, is in an excellent position. The stable is well stocked. There is a new aircraft or a follow-on aircraft for each operational air warfare specialty.

- The fighter community (VF) has the F-4E, soon to be replaced by the F-14 (High Mix) and the F-18 (Low Mix)

- The light attack (VAL) community has replaced the A-4 with A-7E's

- The heavy attack (VAH) community has replaced the A-3 with the A-6

- Land based ASW patrol (VP) squadrons have the computerized P-3C's and upgraded P-3B's

- Carrier based ASW search (VS) squadrons have replaced the S-2 with the sophisticated S-3A

- Carrier based radar early warning (EW) and command and control is provided by the E-2C

Working with this aircraft base places NASC in an extremely favorable position. There are those who might still question whether a prototype strategy can be used when an IOC is driving aircraft development. There is no question, however, that, "A prototype plan will work when no aircraft are urgently needed, and we have a good inventory now. Timing is important."[22]

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[22] Interview with senior official, Department of the Navy, August 26, 1976.

Because the timing is now right, it is incumbent upon the Naval Air Systems Command to implement a Prototype Acquisition Strategy and to prepare for the orderly planning, development and testing for tomorrow's replacement aircraft. "We have got to do it right the first time; we can't afford not to."[23]

The Vehicle is Available. The implenentation of a prototype acquisition strategy could initially be promulgated by NASC instruction. The Naval Aviation Plan is published by the Department of the Navy annually at the end of June. This document is the ideal vehicle to carry policy, guidance, and time-phased priorities of the Department of the Navy and the NASC Commander into all levels of the working organization. The Naval Aviation Plan is essentially boilerplate and currently "provides little in the way of useful planning or management information to NASC personnel."[24] The Naval Aviation Plan is, however, "considered an ideal means of reaching those within the NAVAIR organization and communicating policy and planning information. That is exactly how I would like to see it used."[25]

Summary

Given the economic necessity, and the reality of a declining budget base for military procurement; given the proven

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[23] Ibid.

[24] Ibid, July 14, 1976.

[25] Ibid, July 28, 1976.

usefulness of the aircraft prototype in reducing risk and providing identifiable costs; given the increasing need for hardware oriented information to satisfy the DSARC process; given that prototyping is an accepted method of acquisition and is likely to remain so; and given that the Naval Air Systems Command currently has the aircraft inventory and management means to implement such a policy, it is now appropriate to implement a prototype policy and acquisition strategy.

It appears most feasible to introduce such a plan at the system command level. Yet, none currently exists for the Naval Air Systems Command. With the prospect of money becoming even more scarce and new program approval increasingly more difficult to obtain, it seems reasonable to now develop a Navy acquisition strategy. Just as the Program Master Plan is the vital document for the Program Manager and his staff--the Naval Aviation Plan should be developed into a document to guide the members of the Naval Air Systems Command to a common goal.

CHAPTER V

SUMMARY AND CONCLUSIONS

Questions Restated

In the course of this paper an attempt has been made to present the process of Naval Aircraft Weapon Systems Development for inspection. Through an understanding of the environment, both external to and within the Naval Air Systems Command, it is possible to focus on the issues of greatest criticality. Utilizing this method we would hope to see whether the economics of defense spending weigh in favor of a prototype policy. To fully accomplish this task, it is necessary to ascertain exactly what is meant by prototyping and what the advantages of a prototype program are in aircraft development and acquisition. With an understanding of the historical uses of prototyping and the current DOD emphasis on pre-production testing, our mission remains unaccomplished unless a determination can be made whether a prototype acquisition strategy should be adopted for the development of naval aircraft.

Answers to the Research Questions

National resources are limited and exceedingly difficult to apply effectively. Unless the dollars allocated for defense are spent wisely and with a dedication stemming from responsibility, the citizens who rely upon the defense establishment for their safety will not give it the money to provide for defense. Weapon system acquisition is a legitimate object of public concern.

As modern aircraft become more complex and more costly, it becomes essential to make correct decisions before long development periods and large dollar investments are committed. Weapon systems must be capable of countering a threat in an envisioned time frame. A failure to achieve this objective negates the entire purpose for which weapons are acquired. The objective of an acquisition program is to develop the best alternatives and to produce effective hardware within a reasonable time frame at the most economical cost. By relating accurately costed weapon systems to their mission effectiveness, a proper comparison of alternatives based on performance becomes feasible. This, then, is the advantage that the prototyping process offers the Department of Defense and its' components. Because defense weapons systems continue to become more costly to replace; because each year* less of the DOD budget is available for weapons acquisition, and because of a history of cost overruns which bring military budget requests under increased Congressional scrutiny, it is essential that all proven methods of cost control and cost effectiveness be applied to the process of weapons acquisition.

A prototype is a tool for lessening technological uncertainty. A prototype as defined by this study, is a full sized, critical sybsystems aircraft utilized for government development and operational testing to obtain design, cost, schedule, and performance confidence. A prototype enables the Program

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*With the single exception of FY 1977

Manager to reduce risk and uncertainty and to make informed judgments regarding alternatives.

Program Management enables the DOD components to acquire viable weapon systems at the lowest total cost while meeting a given schedule. This simply stated objective is fraught with problems. The primary problem is one of reducing the high cost risks associated with unknown technologies while scheduling to meet stated Initial Operational Capability (IOC) dates. In some cases, the IOC date is firmly stated since no defense for an enemy threat yet exists; or, because the service life of a present weapons systems cannot be further extended. In still other cases, there is the realization that technology may become obsolete before it can be packaged and delivered to the operating forces.

The prime objective of acquisition management then is to compress the acquisition process to an irreduceable minimum while answering all questions necessary to eliminate production risk. The true test, however, is not that a weapons system can be delivered at target cost and schedule--but that it provides the military user with an effective military platform which is both capable and supportable in countering an enemy threat.

Prototyping has been used in the acquisition process to reduce the risk associated with paper studies and paper cost estimates. Historically, prototyping has informed those monitoring and controlling a program that an experimental concept was invalid, or that a technology could not successfully be

applied to a military use, or that a proposed military system did not possess the utility or tactical capability necessary to justify its production with the attendant expenditure of scarce resources.

Although the prototype is accepted as a method of examining unknowns, its ultimate function has been to provide "No-Go" information to decision makers. Feedback from experimental prototypes has had a predominantly negative connotation. The preproduction prototype also provides negative feedback in the sense that deficiencies are identified only after hard tooling has occurred and it is too late to affect production changes for early lot aircraft.

It is here that the critical subsystems prototype provides positive information to the decision maker early in the Validation and Full Scale Development phases. The prototype has proven that it can identify and minimize cost, schedule and performance risks. It assists in preventing an incremental approach by a contractor whose lack of definition might otherwise permit a production buy-in. Finally, the prototype permits an earlier configuration baseline, thus reducing changes which adversely impact both operating and support costs during the years that a weapon system is maintained in a service inventory.

The prototype does not necessarily add additional cost or time to a program as is commonly believed. It does, however, permit the service component to design to unit production cost and to accurately identify life cycle costs which are critical

inputs to the service acquisition manager and to the Secretary of Defense. This information permits balance of programs decicions within the dollar limits appropriated by the Congress.

Personnel within the Naval Air Systems Command do not have ready access to information which indicates what systems the service needs with what priority. The organization could obtain a higher productivity by providing its personnel with needs, objectives and priorities. It is maintained that an acquisition strategy should be adopted for the development of Naval Aircraft; and, that the strategy should rely upon the proven advantages of a competitive, prototype program initiated during the validation phase of aircraft development.

Many factors mitigate in favor of such a strategy. There is a continuing need for greater economy in allocating scarce resources. The prototype is a proven method of reducing risk and determing realistic cost estimates. The DSARC process for program approval requires the type of information most easily and readily obtained from a prototype program. Aircraft prototyping is being, and has been, used successfully by other branches of the armed services. There is increasing evidence to support the contention that prototyping is the method most desired by the Department of Defense and the Congress. The Naval Air Systems Command is in the advantageous position of having a modern aircraft available to meet each warfare specialty requirement. A prototype strategy can be used to maximum advantage when schedule, in the form of an Initial Operational Capability requirement date, is not a driving factor.

Because all factors favor a strategy of prototyping and because there are no major factors to raise against its use, it is most appropriate to implement a prototype policy as part of a strategy for the acquisition of Naval Aircraft.

Other Remarks

While it might be possible to omit Chapter I because the material is readily accepted as non-controversial, the material provides a valid premise upon which the foundation of this study rests. It should be stated that it is not normally within the pervue of the writer to say what is correct for the Department of the Navy, or what should be policy for the Naval Air Systems Command. Yet, within the context of severely constrained economic resources, and the decision to use resources in the public rather than the private sector--it is the responsibility of each member of an organization to internalize organizational goals and to express alternative ways in which the organization may become more efficient and more effective. This is a prime consideration which public service demands.

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° Rear Admiral R.G. Freeman III, USN; Director Naval Weapons Center, China Lake, California.

° Rear Admiral F.H. Baughman, USN; Vice Commander, Naval Air Systems Command.

° Rear Admiral E.R. Seymour, USN; Deputy for Plans and Programs, Naval Air Systems Command.

° Captain R.L. von Gerichten, USN; Director of Advanced System Directorate, Naval Air Systems Command.

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